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Globe Artichoke Trials 1998, 2000 Management of Yield Using Induced or Natural Vernalization

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SUMMARY

During 1998 and 2000, experiments with globe artichokes were conducted at Mt. Carmel (coastal, loamy, upland soil) to evaluate the yield and quality of newly-developed cultivars designed for annual production from seed. Imperial Star, Emerald, and Amethyst are reported to vernalize with relatively short exposure (250 hours) to temperatures below 50F compared to Green Globe and Green Globe Improved, which require longer exposure (500 hours). Imperial Star, Emerald, and Amethyst are thought to vernalize naturally in cool spring temperatures, while Green Globe and Green Globe Improved may require controlled induced vernalization in a refrigerator.

In 1998, Imperial Star with induced vernalization produced 2.4 buds/plant compared to 3.9 buds/plant with natural vernalization. The main stems of plants with natural vernalization were more branching with tertiary buds that developed along the main stem often reaching marketable size. In 2000, Green Globe produced 5.7 buds/plant followed by Imperial Star with 5.0 buds/plant. Among all cultivars, Emerald had the fewest buds/plant (3.8), but their average weight was greatest (6.5 ounces/bud). Average bud weight of Imperial Star and Amethyst also exceeded 6.0 ounces.

Harvest span of Imperial Star with induced vernalization was 15.7 weeks, and 12.8 weeks for plants with natural vernalization. Despite the longer harvest span for plants with induced vernalization, 86% of the buds were harvested from mid-July to mid-August. In 2000, the harvest span of plants with natural vernalization was 16.1 weeks.

For maximum production of Green Globe buds, induced vernalization followed by gibberellic acid treatment in the six-leaf stage may be required. For Imperial Star, Emerald, and Amethyst, natural vernalization in a cold frame without gibberellic acid treatment produced satisfactory yields and eliminated the need for greenhouse space.

Globe Artichoke Trials 1998, 2000

Management of Yield Using Induced or Natural Vernalization

BY DAVID E. HILL

The globe artichoke (*Cynara scolymus)* is a thistle-like vegetable that was first enjoyed by Romans centuries before Christ (Splittstoesser 1979). It is a native of the Mediterranean area grown predominantly in Italy and France. Spanish and French colonists brought them to America where they flourished in California.

Perennial culture requires cool summers and mild winters. Under these conditions, artichokes grown from root stocks produce continuously for 4-5 years (Ryder, et al. 1982). When grown from seed, the artichoke plant is a biennial, producing vegetatively the first year and producing edible buds the second year. This two-year cycle requires frost-free winters for survival. In Connecticut, survival of artichoke plants during harsh winters is virtually impossible. The growth cycle, however, can be shortened to 5-6 months by vernalization (cool, moist treatment) of germinating seed and application of gibberellic acid (GA3) to young plants (Gerakis et al. 1969). I first demonstrated that these techniques enable satisfactory production of buds in Connecticut on plants grown as annuals (Hill 1987).

Earlier attempts at growing artichokes from seed produced plants that were highly variable with buds of inferior quality (Yamaguchi 1983). Recent breeding programs have produced hybrids that are genetically more uniform. Imperial Star was developed for use in Southern California winter vegetable growing areas (Schrader and Mayberry 1992). Similarly, Emerald and Amethyst were developed for the winter growing area of Arizona. These cultivars not only provide buds of more uniform quality, but the plants are easily vernalized.

Present outlook. In 1985, I became interested in the annual culture of globe artichokes after noting that 40% of California's crop was shipped to regional markets in New York and Boston (Anon 1985). In 1998, fully 5,250 tons of artichokes were shipped to these same East Coast markets (Anon 2000). Following earlier reports on the annual culture of globe artichokes (Hill 1987, 1992, and Hill and Maynard 1989), keen interest was expressed by several commercial growers and numerous home gardeners. Connecticut-grown artichokes are seasonally offered at some roadside stands and farmer's markets, others are grown for specialty food store and restaurant accounts.

In this bulletin, I evaluate new annual cultivars that can be grown with natural vernalization (cool spring temperatures in a cold frame) and compare them with older cultivars that require induced vernalization (controlled cool moist temperatures in a refrigerator). Plants with induced and natural vernalization were evaluated for yield, bud weight, quality, and harvest duration.

SOILS, RAINFALL, AND CUMULATIVE 50F TEMPERATURE

Soils. The globe artichoke trials (1998, 2000) were conducted at Lockwood Farm, Mt. Carmel (Hamden) on Cheshire fine sandy loam, a well-drained upland soil with moderate moisture holding capacity. This soil has no compacted subsoil layers to restrict the growth of the artichoke plant's prominent tap root.

Rainfall. Rainfall distribution throughout the growing season (April-October) for 1998 and 2000 is shown in Table 1. Rainfall in each column represents the departure

from the 30-year average monthly rainfall for Mt. Carmel reported by the National Weather Service. Total rainfall during the 1998 and 2000 growing seasons was 33.9 and 32.7 inches, respectively, compared to a 30-year average of 25.0 inches. Although total rainfall during the 1998 growing season was nearly 9.0 inches above normal, deficits of 2.2 and 1.8 inches occurred in July and September, respectively.

Table 1. Departure from normal rainfall (inches) during the 1998 and 2000 growing seasons (April - October) at Mt. Carmel.

	30-Year Average	1998	2000
April	4.0	1.2	1.5
May	3.7	2.3	0.8
June	2.5	7.5	4.3
July	3.2	-2.2	4.7
August	3.9	2.0	0.4
September	4.2	-1.3	0.2
October	3.3	0.2	-2.5

In 2000, rainfall throughout the growing season was 7.7 inches above normal with 24.8 inches falling between April and July. Despite deficits in August and October, the 2000 growing season was characterized by abundant water for excellent growth and yields. A drip irrigation system was installed in 2000 following the severe drought of 1999 which severely stunted the plants and drastically curtailed yields. The new system, however, was not needed.

Cumulative 50F temperature. In 1998, there were 319 cumulative hours with ambient temperatures below 50F between April 10 (seedlings placed in a cold frame) and May 5 (seedlings planted in the field). In 2000, whose spring was abnormally cool, there were 618 cumulative hours with ambient temperatures below 50F between April 7 and May 17. In addition, there were 238 cumulative hours with temperatures below 50F near the end of the harvest season, between September 25 and October 16.

METHODS AND MATERIALS

Cultivars. In 1998, the only cultivar tested was Imperial Star, a cultivar designed for annual culture from seed and features low vernalization requirements to trigger bud formation (estimated to be less than 250 cumulative hours below 50F). In 2000, two cultivars with similar low vernalization requirements, Emerald and Amethyst, were added. For comparison Green Globe and Green Globe Improved, used in earlier trials (Hill 1987, 1993, Hill and Maynard 1989), were grown to determine their production in plants with natural vernalization. These cultivars are thought to be similar to those that require at least 500 hours of temperatures below 50F for vernalization. (Basnizki 1985).

Vernalization procedure. Vernalization is the metabolic process that causes a plant to change from a vegetative stage to a reproductive stage. This change may be induced by subjecting the germinating seed or growing plant to a cool, moist treatment. In 1998, germinating seeds and seedlings of Imperial Star were treated to two different levels of cold treatments, "induced" and "natural". Pertinent dates for vernalization, hardening and planting are listed in Table 2. Induced vernalization was initiated February 8. After soaking the seed in tap water at room temperature for two days to soften the seed coat, they were packed in moist unshredded sphagnum moss in an unsealed one-gallon plastic bag and refrigerated for four weeks at 36-40F. The seeds were examined weekly and moistened, if necessary. In early March, four-week-old germinated seed with roots extending ¼ to ¾ inch were transferred to 1-quart black plastic containers filled with Promix BX and placed, closely packed, in a greenhouse maintained at 50-75F. If temperatures exceeded 85 during the day, the seedlings were sprayed with cold water early in the afternoon to prevent devernalization (Harwood and Markarian 1968). Perimeter containers, fully exposed to sunlight, were draped with aluminum foil to prevent excessive heat absorption through the wall of the black container. About 20% extra seedlings were grown to allow culling of weak plants as they were transplanted in the field.

Seedlings in the 4-leaf stage were transferred to a cold frame for hardening. Seedlings were covered at night only on the threat of frost. Uncovered seedlings were inadvertently subjected to night temperatures as low as 29F without apparent injury.

Natural vernalization began on March 6. As before, pre-soaked seeds were placed in an unsealed one-gallon plastic bag filled with unshredded sphagnum moss, but left at room temperature (65-70F). After 10 days, germinated seeds were planted in one-quart pots and placed in a greenhouse until the first true leaves began to form. In early April, they were transferred to a cold frame for early growth and vernalization until they were ready for transplanting at the 4-leaf stage.

Fertilization. Soluble 20-20-20 fertilizer (1 tbsp/gal) was added to the potted seedlings about 10 days before transplanting. The field soil was fertilized with 10-10-10 at a rate of 1300 lb/A before transplanting. The pH of the soil was 6.5 and did not require liming.

Field transplanting. In 1998, seedlings with induced vernalization were transplanted in early May; those with natural vernalization in early June (Table 2). In 2000, seedlings with natural vernalization were transplanted in early May when they had reached the 4-leaf stage.

All transplants were spaced two feet apart in rows four feet apart, a plant density of 5,445 plants/A. The holes for the transplants were sufficiently deep to accommodate the tap root that usually coiled at the bottom of the pot. In 1998, two 50-foot rows each of seedlings with induced and natural

Table 2. Pertinent dates for vernalizing, hardening, and transplanting artichoke seedlings—Mt. Carmel, 1998, 2000.

Activity	1998	2000
Induced vernalization		
Vernalized germination seed in refrigeration	February 8	_
Plants in pots in greenhouse	March 4	_
Transfer to cold frame for hardening	April 10	_
Transplant in field	May 5	_
Natural vernalization		
Germinate seed at room temperature	March 6	March 3-13
Plant in pots in greenhouse	March 16	March 10-20
Transfer to cold frame for vernalization	April 28	April 7-11
Transplant in field	June 2	May 18

vernalization were planted (50 plants each).

In 2000, the five artichoke cultivars were planted in five 60-foot rows with similar plant spacing (2 X 4 feet). Each cultivar was randomly planted in each of the five replicated rows. Each replication contained five plants of each cultivar, a total of 25 plants/cultivar.

Mulching. Summer heat may cause devernalization of unprotected plants. Immediately after transplanting, the soil was cooled with four inches of undecomposed leaf mulch. Although it was necessary to mulch only within 12 inches around the plant, the remaining space between the rows was mulched to control weeds.

Irrigation. In 1998, the crop was irrigated twice in July to maintain an adequate supply of water. In 2000, no irrigation was necessary throughout the growing season.

Gibberellic acid treatment. Gibberellic acid (GA3) is a natural plant hormone found in most herbaceous plants. Its use in artichoke culture initiates bud formation and speeds their development in barren plants (Gerakis et al. 1962). Its use to promote budding in cultivars that require long exposure to low temperature requirements for vernalization assured development of buds in 80-85% of plants, especially in years with limited spring rainfall (Hill and Maynard 1998). On July 15, 1998, all barren plants with induced vernalization that had failed to form buds (6 of 50 plants) were sprayed with 50 ppm GA3, directed to the center of the plant surrounding the growing tip. On August 19.1998, 17 of 50 plants with natural vernalization remained barren and were similarly sprayed with 50 ppm GA3.

In 2000, all barren plants (22 of 125) in mid-August remained untreated to determine whether they would eventually produce buds as fall temperatures cooled.

Harvest. The buds were harvested at 7-10-day intervals before the lower bracts began to spread. Artichokes weighing less than 2.5 ounces were discarded. These discards were smaller than the 60 size class (60 buds/standard box), the smallest commercial grade.

YIELD OF BUDS

In 1998, plants with induced vernalization produced 2.4 buds/plant compared to 3.9 buds/plant with natural vernalization (Table 3). Harvest of buds on plants with induced vernalization began about three weeks earlier than plants with natural vernalization, a consequence of earlier planting. The plants with induced vernalization were not as large as those with natural vernalization at the time of first harvest. The main stem of plants with induced vernalization displayed little branching. Plants with one primary artichoke and two secondary artichokes were most common. In plants with natural vernalization, the main stem was thicker and produced additional smaller artichokes at leaf axils along the main stem. Many of these tertiary buds reached marketable size. There was little difference in the average bud weight from plants grown with either vernalization technique. Three of 50 plants that produced their buds early in July produced a second crop of marketable buds in October from basal sprouts that developed after the main stem withered. This is consistent with earlier observations (Hill 1987) with the cultivar Green Globe.

Table 3. Yield of Imperial Star buds from plants with induced vernalization vs. natural vernalization at Mt. Carmel, 1998

	Plants Producing %	Buds/ Plant No.	Wt./ Bud Oz	Total Yield* No. buds/A
Induced vernalization	92	2.4	5.5	12,020
Natural vernalization	90	3.9	5.7	19,110

* Based on 5445 plants/A (2X4 foot spacing) X buds/plant % plants producing

Plants with natural vernalization produced an estimated 19,000 buds/A compared to 12,000 buds/A for plants with induced vernalization (Table 3).

In 2000, all naturally vernalized cultivars responded well to the benefits of an extended period of cool, moist weather in spring. Among all cultivars, Green Globe had the greatest number of buds/plant (5.7), followed by Imperial Star (Table 4). Emerald had the fewest buds/plant, but their average weight was greatest (6.5 ounces/bud). The average weight/bud of Imperial Star and Amethyst was equal to or greater than 6.0 ounces. Green Globe had fewer plants producing buds than all other cultivars. All Green Globe plants that remained barren at the end of the growing season were stunted despite rigorous culling during planting. The productive plants of Green Globe were larger than average with multiple branching of the main stem. Many tertiary buds developed at the leaf axils. Two individual plants produced nine marketable buds. These plants were fully two feet taller than other plants in the trial, illustrating the diversity of Green Globe planted from seed. Total estimated yield of Imperial Star, and Green Globe exceeded 25,000 buds/A. Although the total estimated yield of Amethyst exceeded 20,000 buds/A, 25% of the plants produced malformed buds. It is unknown whether the defect was a physiological disorder or a genetic abnormality. No other cultivars produced malformed buds.

Table 4. Yield of artichoke buds from plants with natural vernalization at Mt. Carmel, 2000.

Cultivar	Plants Producing %	Buds/ Plant No.	Wt/ Bud Oz	Total Yield Buds* No/A
Imperial Star	100	5.0	6.1	27,225
Emerald	96	3.8	6.5	19,865
Amethyst	92	4.1	6.0	20,540
Green Globe	72	5.7	5.6	22,345
Green Globe Imp.	100	4.6	5.8	25,045

* Based on 5445 plants/A (2 x 4-foot spacing) x buds/plant x % plants producing

HARVEST SPAN

In 1998, the first buds from plants with induced vernalization were harvested on July 17. Buds from plants with natural vernalization were first harvested on August 6, about three weeks later. All harvests concluded November 4, a harvest span of 15.7 weeks for plants with induced vernalization and 12.8 weeks for plants with natural vernalization. Despite the long harvest span of plants with induced vernalization, fully 86% of the buds were harvested between July 17 and August 27, a 5.9-week span. The remaining 14% were harvested between September 9 and November 4, mostly from barren plants that had been treated with GA3 on August 19.

In 2000, harvest from all naturally vernalized plants began on July 28 and ended on November 18, a span of 16.1 weeks. Buds harvested after October 23 were "frost kissed" a term used in the artichoke industry to describe buds whose thin, waxy cuticle had been ruptured by frost. This condition is a cosmetic defect and does not affect the taste of the artichoke.

GIBBERELLIC ACID TREATMENT OF BARREN PLANTS

In 1998, GA3 treatment of barren plants in mid-August initiated bud formation in two of six plants with induced vernalization and 12 of 17 barren plants with natural vernalization (Table 5).

Table 5. Treatment of barren artichoke plants on August 19 with GA3 (1998) or left untreated (2000).

1998—Treated	Barren No. August 18	Barren No. Sept. 24	% of Plants
Induced vernalization	6	4	8
Natural vernalization	17	5	10
2000—Untreated	Barren No. August 24	Barren No. October 23	% of Plants
Amethyst	6	2	8
Emerald	3	1*	4
Imperial Star	2	0	0
Green Globe	7	7	28
Green Globe Imp.	2	0	0

* Bud formed but too late to attain marketable size.

If untreated, would these barren plants eventually produce buds if vernalization was delayed until fall when cooler temperatures prevailed? In 2000, 2-7 plants of each cultivar were barren on August 24. By October 23, most of these plants had produced buds without GA3 treatment. The notable exception was Green Globe, whose seven barren plants did not respond to cool fall temperatures. Despite being exposed to 618 hours of temperatures below 50F during spring, these plants never produced buds. These plants were stunted and probably would not have borne marketable buds even if they had developed.

MANAGEMENT STRATEGIES

Cultivar selection. There are limited cultivars available for use in annual production from seed. Imperial Star and Emerald produce attractive buds for retail sale. The buds of Imperial Star are thornless, glossy and grayish-green in color (Schrader and Mayberry 1992). The bracts are slow to

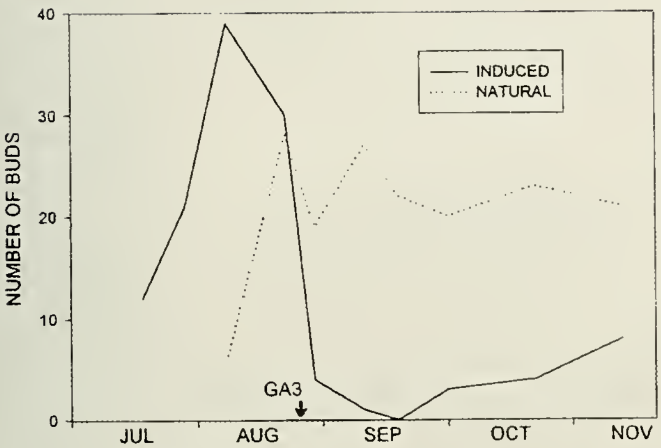

Figure 1. Distribution of artichokes throughout the growing season from plants with induced and natural vernalization, 1998.

spread, an advantage if harvests are delayed. The buds of Emerald are more elongated than Imperial Star. Their glossy, green bracts are large and meaty and their hearts are large. Although the number of buds/plant was lower than other cultivars, the plants produced a larger percentage of buds in the 24-36 size grades.

Green Globe and Green Globe Improved were also selected for annual culture. Both are reliable cultivars but some buds are thorny. In earlier trials, both responded well to induced vernalization. In 2000, when spring temperatures were unusually cool, natural vernalization of all cultivars assured above-normal yields.

Gibberellic acid treatment? In earlier trials, treatment of barren plants in late July through early August was beneficial only to Green Globe, which required extended low temperatures (less than 50F) for vernalization. Barren plants of cultivars that require fewer hours of cold temperature (Imperial Star, Emerald, and Amethyst) eventually produced buds as fall temperatures lowered.

Vernalization: induced or natural? There are several advantages of natural vernalization that begins in March. The need for greenhouse space is avoided, which results in a savings in production costs. For commercial growers or home gardeners, natural vernalization permits harvest of buds in early August through October. At this time, California production is meager as fields rest between crops. For growers with greenhouse space, the production of artichokes from plants with induced vernalization provides maximum harvest from early July through late August. During these months, direct marketing of artichoke buds through roadside stands and farmer's markets permits retail prices that are independent of California wholesale prices.

Growers may wish to consider producing two artichoke crops, one grown from plants with induced vernalization and one grown from plants with natural vernalization. Figure 1 illustrates that early production in mid-July through late August from plants with induced vernalization is replaced by production from plants with natural vernalization. Although production from plants with induced vernalization drops sharply in late August, additional production in September and October stems from barren plants that were treated with gibberellic acid in August and also from plants that died back and re-sprouted to produce a second crop.

Connecticut growers who have produced artichokes from seed report that the advantages of freshness and taste appeal bring customers back for repeat sales

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